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Date: July 3, 2003


Docket No. 1/1192-1-C1

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By:

  
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**Pharmaceutical Compositions based on Anticholinergics and  
PDE-IV inhibitors**

This application is a continuation in part of  
5 Provisional Patent Application 60/281,857, filed April 5,  
2001.

The present invention relates to novel pharmaceutical  
compositions based on anticholinergics and PDE-IV inhibitors,  
10 processes for preparing them and their use in the treatment  
of respiratory diseases.

Description of the invention

The present invention relates to novel pharmaceutical  
15 compositions based on anticholinergics and PDE-IV inhibitors,  
processes for preparing them and their use in the treatment  
of respiratory diseases.

Surprisingly, an unexpectedly beneficial therapeutic effect,  
particularly a synergistic effect can be observed in the  
20 treatment of inflammatory and/or obstructive diseases of the  
respiratory tract if one or more, preferably one,  
anticholinergic is used with one or more, preferably one,  
PDE-IV inhibitor. In view of this synergistic effect the  
pharmaceutical combinations according to the invention can be  
25 used in smaller doses than would be the case with the  
individual compounds used in monotherapy in the usual way.  
Furthermore, this reduces unwanted side effects such as may  
occur when PDE-IV inhibitors are administered, for example.

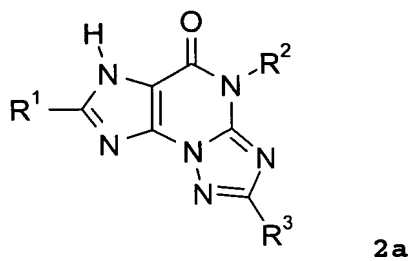
The effects mentioned above may be observed both when the two  
30 active substances are administered simultaneously in a single  
active substance formulation and when they are administered  
successively in separate formulations. According to the

invention, it is preferable to administer the two active substance ingredients simultaneously in a single formulation.

Within the scope of the present invention the term anticholinergics 1 denotes salts which are preferably  
5 selected from among tiotropium salts, oxitropium salts and ipratropium salts, most preferably ipratropium salts and tiotropium salts. In the above-mentioned salts the cations tiotropium, oxitropium and ipratropium are the  
10 pharmacologically active ingredients. Within the scope of the present patent application, any reference to the above cations is indicated by the use of the number 1'. Any reference to compounds 1 naturally also includes a reference to the ingredients 1' (tiotropium, oxitropium or ipratropium).

15 By the salts 1 which may be used within the scope of the present invention are meant the compounds which contain, in addition to tiotropium, oxitropium or ipratropium as counter-ion (anion), chloride, bromide, iodide, methanesulphonate or para-toluenesulphonate. Within the  
20 scope of the present invention, the methanesulphonate, chloride, bromide and iodide are preferred of all the salts 1, the methanesulphonate and bromide being of particular importance. Of outstanding importance according to the invention are salts 1 selected from among tiotropium bromide,  
25 oxitropium bromide and ipratropium bromide. Tiotropium bromide is particularly preferred.

Within the scope of the present invention, the word PDE-IV inhibitors (hereinafter 2) denotes compounds selected from  
among enprofylline, roflumilast, ariflo, Bay-198004, CP-  
30 325,366, BY343, D-4396 (Sch-351591), V-11294A, AWD-12-281 and the tricyclic nitrogen heterocycles of general formula 2a



wherein

- 5     R<sup>1</sup>       denotes C<sub>1</sub>-C<sub>5</sub>-alkyl, C<sub>5</sub>-C<sub>6</sub>-cycloalkyl, phenyl, benzyl or a 5- or 6-membered, saturated or unsaturated heterocyclic ring which may contain one or two heteroatoms selected from among oxygen and nitrogen;
- 10    R<sup>2</sup>       denotes C<sub>1</sub>-C<sub>5</sub>-alkyl or C<sub>2</sub>-C<sub>4</sub>-alkenyl;
- 15    R<sup>3</sup>       denotes C<sub>1</sub>-C<sub>5</sub>-alkyl which may optionally be substituted by C<sub>1</sub>-C<sub>4</sub>-alkoxy, C<sub>5</sub>-C<sub>6</sub>-cycloalkyl, phenoxy or a 5- or 6-membered, saturated or unsaturated heterocyclic ring which may contain one or two heteroatoms selected from among oxygen and nitrogen;
- 20           C<sub>5</sub>-C<sub>6</sub>-cycloalkyl or phenyl or benzyl optionally substituted by C<sub>1</sub>-C<sub>4</sub>-alkoxy, optionally in the form of their racemates, their enantiomers, in the form of the diastereomers and the mixtures thereof, optionally in the form of their tautomers and optionally the pharmacologically acceptable acid addition salts thereof.

25    Of the abovementioned compounds of **2a** those which are preferably used within the scope of the present invention are those compounds of formula **2a** wherein

- 30    R<sup>1</sup>       denotes C<sub>1</sub>-C<sub>4</sub>-alkyl, C<sub>5</sub>-C<sub>6</sub>-cycloalkyl, tetrahydrofuranyl, tetrahydropyranyl, piperazinyl, morpholinyl or phenyl;
- R<sup>2</sup>       denotes C<sub>1</sub>-C<sub>4</sub>-alkyl or C<sub>2</sub>-C<sub>4</sub>-alkenyl;

R<sup>3</sup> denotes C<sub>1</sub>-C<sub>4</sub>-alkyl which may optionally be substituted by C<sub>1</sub>-C<sub>4</sub>-alkoxy, C<sub>5</sub>-C<sub>6</sub>-cycloalkyl, phenoxy, (C<sub>1</sub>-C<sub>4</sub>-alkoxy)phenyloxy, piperazine or pyrrole, C<sub>5</sub>-C<sub>6</sub>-cycloalkyl or phenyl or benzyl optionally substituted by C<sub>1</sub>-C<sub>4</sub>-alkoxy, optionally in the form of their racemates, their enantiomers, in the form of the diastereomers and the mixtures thereof, optionally in the form of their tautomers and optionally the pharmacologically acceptable acid addition salts thereof.

Of the compounds of formula 2a those which are most preferably used within the scope of the present invention are those compounds of formula 2a wherein

R<sup>1</sup> denotes ethyl, propyl, butyl, cyclopentyl, tetrahydrofuranyl, tetrahydropyranyl, N-morpholinyl or phenyl;  
 R<sup>2</sup> denotes ethyl, propyl, allyl or butenyl;  
 R<sup>3</sup> denotes ethyl, propyl, butyl, cyclopentyl, cyclohexylmethyl, benzyl, phenylethyl, phenoxymethyl, methoxybenzyl or N-pyrollylmethyl, optionally in the form of their racemates, their enantiomers, in the form of the diastereomers and the mixtures thereof, optionally in the form of their tautomers and optionally the pharmacologically acceptable acid addition salts thereof.

Most preferably, the compounds used as component 2 are the compounds of formula 2a wherein

R<sup>1</sup> denotes ethyl, n-propyl, tert-butyl, cyclopentyl, 3-tetrahydrofuryl, N-morpholinyl or phenyl;  
 R<sup>2</sup> denotes ethyl or n-propyl;  
 R<sup>3</sup> denotes ethyl, i-propyl, n-propyl, n-butyl, t-butyl, cyclopentyl, cyclohexylmethyl, benzyl, phenylethyl, phenoxymethyl, 4-methoxybenzyl or

N-pyrrollylmethyl, optionally in the form of their racemates, their enantiomers, in the form of the diastereomers and the mixtures thereof, optionally in the form of their tautomers and optionally the pharmacologically acceptable acid addition salts thereof.

Examples of alkyl groups (including those which are part of other groups) are branched and unbranched alkyl groups with 1 to 5 carbon atoms, such as, for example: methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec. butyl, tert.butyl, n-pentyl, isopentyl or neopentyl. The abbreviations Me, Et, n-Pr, i-Pr, n-Bu, i-Bu, t-Bu, etc. may optionally be used for the abovementioned groups.

Examples of cycloalkyl groups with 5 or 6 carbon atoms include cyclopentyl or cyclohexyl. Examples of 5- or 6-membered, saturated or unsaturated heterocyclic rings which may contain one or two heteroatoms selected from among oxygen and nitrogen include: furan, tetrahydrofuran, tetrahydrofuranon,  $\gamma$ -butyrolactone,  $\alpha$ -pyran,  $\gamma$ -pyran, dioxolan, tetrahydropyran, dioxan, pyrrole, pyrroline, pyrrolidine, pyrazole, pyrazoline, imidazole, imidazoline, imidazolidine, pyridine, piperidine, pyridazine, pyrimidine, pyrazine, piperazine, morpholine, oxazole, isoxazole, oxazine and pyrazolidine.

Table 1 lists the compounds of general formula 2a which are most preferably used in conjunction with the compounds 1 within the scope of the invention.

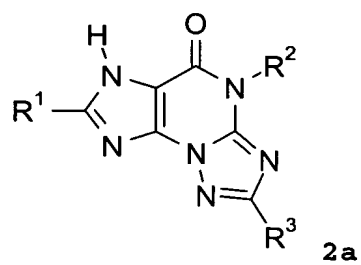


Table 1:

No.	R <sup>1</sup>	R <sup>2</sup>	R <sup>3</sup>
1	cyclopentyl	n-propyl	i-propyl
2	cyclopentyl	n-propyl	ethyl
3	t-butyl	ethyl	4-methoxybenzyl
4	cyclopentyl	ethyl	-CH <sub>2</sub> CH <sub>2</sub> phenyl
5	3-tetrahydrofuryl	ethyl	benzyl
6	cyclopentyl	n-propyl	n-propyl
7	t-butyl	ethyl	benzyl
8	phenyl	n-propyl	n-propyl
9	cyclopentyl	ethyl	benzyl
10	-n-propyl	-n-propyl	benzyl
11	cyclopentyl	ethyl	N-pyrrolylmethyl
12	cyclopentyl	-n-propyl	benzyl
13	cyclopentyl	-n-propyl	-t-butyl
14	cyclopentyl	n-propyl	n-butyl
15	cyclopentyl	ethyl	-CH <sub>2</sub> -Ophenyl
16	N-morpholinyl	-n-propyl	benzyl
17	cyclopentyl	ethyl	cyclohexylmethyl
18	ethyl	ethyl	cyclohexylmethyl
19	n-propyl	n-propyl	cyclopentyl

- 5 The compounds of general formula **2a** may be prepared analogously to the method described in the prior art for certain of the above-defined compounds of general formula (I) (Tenor et al., *Chem. Ber.* Vol. 97 (1964) p. 1373-1382), to which reference is hereby made.

Preferably, also, the compound 2 is selected from among enprofylline, roflumilast, ariflo and AWD-12-281, while AWD-12-281 and the abovementioned compounds of formula 2a are particularly preferred as compound 2 according to the  
5 invention.

Any reference to the abovementioned PDE-IV inhibitors 2 within the scope of the present invention includes a reference to any pharmacologically acceptable acid addition  
10 salts thereof which may exist.

By the physiologically acceptable acid addition salts which may be formed from 2 are meant, for example, pharmaceutically acceptable salts selected from the salts of hydrochloric acid, hydrobromic acid, sulphuric acid, phosphoric acid,  
15 methanesulphonic acid, acetic acid, fumaric acid, succinic acid, lactic acid, citric acid, tartaric acid or maleic acid. Particularly preferred salts of the compounds 2 according to the invention are those selected from among the acetate, hydrochloride, hydrobromide, sulphate, phosphate and  
20 methanesulphonate.

The pharmaceutical combinations of 1 and 2 according to the invention are preferably administered by inhalation. Suitable inhalable powders packed into suitable capsules (inhalettes) may be administered using suitable powder  
25 inhalers. Alternatively, the drug may be inhaled by the application of suitable inhalation aerosols. These also include inhalation aerosols which contain HFA134a (also known as TG134a), HFA227 (also known as TG227) or a mixture thereof as propellant gas. The drug may also be inhaled using  
30 suitable solutions of the pharmaceutical combination consisting of 1 and 2.



In one aspect, therefore, the invention relates to a pharmaceutical composition which contains a combination of 1 and 2.

5 In another aspect the present invention relates to a pharmaceutical composition which contains one or more salts 1 and one or more compounds 2, optionally in the form of their solvates or hydrates. Again, the active substances may be combined in a single preparation or contained in two separate formulations. Pharmaceutical compositions which contain the  
10 active substances 1 and 2 in a single preparation are preferred according to the invention.

In another aspect the present invention relates to a pharmaceutical composition which contains, in addition to therapeutically effective quantities of 1 and 2, a  
15 pharmaceutically acceptable excipient. In another aspect the present invention relates to a pharmaceutical composition which does not contain any pharmaceutically acceptable excipient in addition to therapeutically effective quantities of 1 and 2.

20 The present invention also relates to the use of 1 and 2 for preparing a pharmaceutical composition containing therapeutically effective quantities of 1 and 2 for treating inflammatory and/or obstructive diseases of the respiratory tract, particularly asthma or chronic obstructive pulmonary  
25 disease (COPD), and complications thereof such as pulmonary hypertension, as well as allergic and non-allergic rhinitis.

The present invention also relates to the simultaneous or successive use of therapeutically effective doses of the combination of the above pharmaceutical compositions 1 and 2  
30 for treating inflammatory and/or obstructive diseases of the respiratory tract, particularly asthma or chronic obstructive

pulmonary disease (COPD), and complications thereof such as pulmonary hypertension, as well as allergic and non-allergic rhinitis, by simultaneous or successive administration.

5 In the active substance combinations of 1 and 2 according to the invention, ingredients 1 and 2 may be present in the form of their enantiomers, mixtures of enantiomers or in the form of racemates.

10 The proportions in which the two active substances 1 and 2 may be used in the active substance combinations according to the invention are variable. Active substances 1 and 2 may possibly be present in the form of their solvates or hydrates. Depending on the choice of the compounds 1 and 2, the weight ratios which may be used within the scope of the present invention vary on the basis of the different  
15 molecular weights of the various compounds and their different potencies. As a rule, the pharmaceutical combinations according to the invention may contain compounds 1 and 2 in ratios by weight ranging from 1:300 to 50:1, preferably from 1:250 to 40:1. In the particularly preferred  
20 pharmaceutical combinations which contain tiotropium salt as compound 1, the weight ratios of 1 to 2 are most preferably in a range in which ipratropium or tiotropium 1' and 2 are present in proportions of 1:150 to 30:1, more preferably from 1:50 to 20:1.

25 For example, without restricting the scope of the invention thereto, preferred combinations of 1 and 2 according to the invention may contain tiotropium 1' and PDE-IV inhibitor 2 in the following weight ratios:

30 1:80, 1:79, 1:78, 1:77, 1:76, 1:75, 1:74, 1:73, 1:72, 1:71, 1:70, 1:69, 1:68, 1:67, 1:66, 1:65, 1:64, 1:63, 1:62, 1:61, 1:60, 1:59, 1:58, 1:57, 1:56, 1:55, 1:54, 1:53, 1:52, 1:51,

1:50; 1:49; 1:48; 1:47; 1:46; 1:45; 1:44; 1:43; 1:42; 1:41;  
 1:40; 1:39; 1:38; 1:37; 1:36; 1:35; 1:34; 1:33; 1:32; 1:31;  
 1:30; 1:29; 1:28; 1:27; 1:26; 1:25; 1:24; 1:23; 1:22; 1:21;  
 1:20; 1:19; 1:18; 1:17; 1:16; 1:15; 1:14; 1:13; 1:12; 1:11;  
 5 1:10; 1:9; 1:8; 1:7; 1:6; 1:5; 1:4; 1:3; 1:2; 1:1; 2:1; 3:1;  
 4:1; 5:1; 6:1; 7:1; 8:1; 9:1; 10:1; 11:1; 12:1; 13:1; 14:1;  
 15:1; 16:1; 17:1; 18:1; 19:1; 20:1.

The pharmaceutical compositions according to the invention  
 containing the combinations of 1 and 2 are normally  
 10 administered so that 1 and 2 are present together in doses of  
 0.01 to 10000µg, preferably from 0.1 to 2000µg, more  
 preferably from 1 to 1500µg, better still from 50 to 1200µg  
 per single dose. For example, combinations of 1 and 2  
 according to the invention contain a quantity of tiotropium  
 15 1' and PDE-IV inhibitor 2 such that the total dosage per  
 single dose is about 100µg, 105µg, 110µg, 115µg, 120µg, 125µg,  
 130µg, 135µg, 140µg, 145µg, 150µg, 155µg, 160µg, 165µg,  
 170µg, 175µg, 180µg, 185µg, 190µg, 195µg, 200µg, 205µg,  
 210µg, 215µg, 220µg, 225µg, 230µg, 235µg, 240µg, 245µg,  
 20 250µg, 255µg, 260µg, 265µg, 270µg, 275µg, 280µg, 285µg,  
 290µg, 295µg, 300µg, 305µg, 310µg, 315µg, 320µg, 325µg,  
 330µg, 335µg, 340µg, 345µg, 350µg, 355µg, 360µg, 365µg,  
 370µg, 375µg, 380µg, 385µg, 390µg, 395µg, 400µg, 405µg,  
 410µg, 415µg, 420µg, 425µg, 430µg, 435µg, 440µg, 445µg,  
 25 450µg, 455µg, 460µg, 465µg, 470µg, 475µg, 480µg, 485µg,  
 490µg, 495µg, 500µg, 505µg, 510µg, 515µg, 520µg, 525µg,  
 530µg, 535µg, 540µg, 545µg, 550µg, 555µg, 560µg, 565µg, 570µg,  
 575µg, 580µg, 585µg, 590µg, 595µg, 600µg, 605µg, 610µg, 615µg,  
 620µg, 625µg, 630µg, 635µg, 640µg, 645µg, 650µg, 655µg, 660µg,  
 30 665µg, 670µg, 675µg, 680µg, 685µg, 690µg, 695µg, 700µg, 705µg,  
 710µg, 715µg, 720µg, 725µg, 730µg, 735µg, 740µg, 745µg, 750µg,  
 755µg, 760µg, 765µg, 770µg, 775µg, 780µg, 785µg, 790µg, 795µg,  
 800µg, 805µg, 810µg, 815µg, 820µg, 825µg, 830µg, 835µg, 840µg,  
 845µg, 850µg, 855µg, 860µg, 865µg, 870µg, 875µg, 880µg, 885µg,

- 890µg, 895µg, 900µg, 905µg, 910µg, 915µg, 920µg, 925µg, 930µg, 935µg, 940µg, 945µg, 950µg, 955µg, 960µg, 965µg, 970µg, 975µg, 980µg, 985µg, 990µg, 995µg, 1000µg, 1005µg, 1010µg, 1015µg, 1020µg, 1025µg, 1030µg, 1035µg, 1040µg, 1045µg, 1050µg,
- 5 1055µg, 1060µg, 1065µg, 1070µg, 1075µg, 1080µg, 1085µg, 1090µg, 1095µg, 1100µg or similar. The suggested dosages per single dose specified above are not to be regarded as being limited to the numerical values actually stated, but are intended as dosages which are disclosed by way of example.
- 10 Of course, dosages which may fluctuate about the abovementioned numerical values within a range of about +/- 2.5 µg are also included in the values given above by way of example. In these dosage ranges, the active substances 1' and 2 may be present in the weight ratios given above.
- 15 For example, without restricting the scope of the invention thereto, the combinations of 1 and 2 according to the invention may contain a quantity of tiotropium 1' and PDE-IV inhibitor 2 such that, for each single dose, 5µg of 1' and 25µg of 2, 5µg of 1' and 50µg of 2, 5µg of 1' and 100µg of 2,
- 20 5µg of 1' and 200µg of 2, 5µg of 1' and 300µg of 2, 5µg of 1' and 400µg of 2, 5µg of 1' and 500µg of 2, 5µg of 1' and 600µg of 2, 5µg of 1' and 700µg of 2, 5µg of 1' and 800µg of 2, 5µg of 1' and 900µg of 2, 5µg of 1' and 1000µg of 2, 10µg of 1' and 25µg of 2, 10µg of 1' and 50µg of 2, 10µg of 1' and 100µg
- 25 of 2, 10µg of 1' and 200µg of 2, 10µg of 1' and 300µg of 2, 10µg of 1' and 400µg of 2, 10µg of 1' and 500µg of 2, 10µg of 1' and 600µg of 2, 10µg of 1' and 700µg of 2, 10µg of 1' and 800µg of 2, 10µg of 1' and 900µg of 2, 10µg of 1' and 1000µg of 2, 18µg of 1' and 25µg of 2, 18µg of 1' and 50µg of 2,
- 30 18µg of 1' and 100µg of 2, 18µg of 1' and 200µg of 2, 18µg of 1' and 300µg of 2, 18µg of 1' and 400µg of 2, 18µg of 1' and 500µg of 2, 18µg of 1' and 600µg of 2, 18µg of 1' and 700µg of 2, 18µg of 1' and 800µg of 2, 18µg of 1' and 900µg of 2, 18µg of 1' and 1000µg of 2, 20µg of 1' and 25µg of 2, 20µg of

1' and 50µg of 2, 20µg of 1' and 50µg of 2, 20µg of 1' and  
 100µg of 2, 20µg of 1' and 200µg of 2, 20µg of 1' and 300µg  
 of 2, 20µg of 1' and 400µg of 2, 20µg of 1' and 500µg of 2,  
 20µg of 1' and 600µg of 2, 20µg of 1' and 700µg of 2, 20µg of  
 5 1' and 800µg of 2, 20µg of 1' and 900µg of 2, 20µg of 1' and  
 1000µg of 2, 36µg of 1' and 25µg of 2, 36µg of 1' and 50µg of  
2, 36µg of 1' and 100µg of 2, 36µg of 1' and 200µg of 2, 36µg  
 of 1' and 300µg of 2, 36µg of 1' and 400µg of 2, 36µg of 1'  
 and 500µg of 2, 36µg of 1' and 600µg of 2, 36µg of 1' and  
 10 700µg of 2, 36µg of 1' and 800µg of 2, 36µg of 1' and 900µg  
 of 2, 36µg of 1' and 1000µg of 2, 40µg of 1' and 25µg of 2,  
 40µg of 1' and 50µg of 2, 40µg of 1' and 100µg of 2, 40µg of  
1' and 200µg of 2, 40µg of 1' and 300µg of 2, 40µg of 1' and  
 400µg of 2, 40µg of 1' and 500µg of 2, 40µg of 1' and 600µg  
 15 of 2 or 40µg of 1' and 700µg of 2, 40µg of 1' and 800µg of 2,  
 40µg of 1' and 900µg of 2, 40µg of 1' and 1000µg of 2 are  
 administered.

If the active substance combination in which 1 denotes  
 20 tiotropium bromide is used as the preferred combination of 1  
 and 2 according to the invention, the quantities of active  
 substance 1' and 2 administered per single dose mentioned by  
 way of example correspond to the following quantities of 1  
 and 2 administered per single dose: 6µg of 1 and 25µg of 2,  
 25 6µg of 1 and 50µg of 2, 6µg of 1 and 100µg of 2, 6µg of 1 and  
 200µg of 2, 6µg of 1 and 300µg of 2, 6µg of 1 and 400µg of 2,  
 6µg of 1 and 500µg of 2, 6µg of 1 and 600µg of 2, 6µg of 1  
 and 700µg of 2, 6µg of 1 and 800µg of 2, 6µg of 1 and 900µg  
 of 2, 6µg of 1 and 1000µg of 2, 12µg of 1 and 25µg of 2, 12µg  
 30 of 1 and 50µg of 2, 12µg of 1 and 100µg of 2, 12µg of 1 and  
 200µg of 2, 12µg of 1 and 300µg of 2, 12µg of 1 and 400µg of  
2, 12µg of 1 and 500µg of 2, 12µg of 1 and 600µg of 2, 12µg  
 of 1 and 700µg of 2, 12µg of 1 and 800µg of 2, 12µg of 1 and  
 900µg of 2, 12µg of 1 and 1000µg of 2, 21.7µg of 1 and 25µg  
 35 of 2, 21.7µg of 1 and 50µg of 2, 21.7µg of 1 and 100µg of 2,

21.7 $\mu$ g of 1 and 200 $\mu$ g of 2, 21.7 $\mu$ g of 1 and 300 $\mu$ g of 2,  
 21.7 $\mu$ g of 1 and 400 $\mu$ g of 2, 21.7 $\mu$ g of 1 and 500 $\mu$ g of 2,  
 21.7 $\mu$ g of 1 and 600 $\mu$ g of 2, 21.7 $\mu$ g of 1 and 700 $\mu$ g of 2,  
 21.7 $\mu$ g of 1 and 800 $\mu$ g of 2, 21.7 $\mu$ g of 1 and 900 $\mu$ g of 2,  
 5 21.7 $\mu$ g of 1 and 1000 $\mu$ g of 2, 24.1 $\mu$ g of 1 and 25 $\mu$ g of 2,  
 24.1 $\mu$ g of 1 and 50 $\mu$ g of 2, 24.1 $\mu$ g of 1 and 100 $\mu$ g of 2, 24.1 $\mu$ g  
 of 1 and 200 $\mu$ g of 2, 24.1 $\mu$ g of 1 and 300 $\mu$ g of 2, 24.1 $\mu$ g of 1  
 and 400 $\mu$ g of 2, 24.1 $\mu$ g of 1 and 500 $\mu$ g of 2, 24.1 $\mu$ g of 1 and  
 600 $\mu$ g of 2, 24.1 $\mu$ g of 1 and 700 $\mu$ g of 2, 24.1 $\mu$ g of 1 and 800 $\mu$ g  
 10 of 2, 24.1 $\mu$ g of 1 and 900 $\mu$ g of 2, 24.1 $\mu$ g of 1 and 1000 $\mu$ g of  
2, 43.3 $\mu$ g of 1 and 25 $\mu$ g of 2, 43.3 $\mu$ g of 1 and 50 $\mu$ g of 2,  
 43.3 $\mu$ g of 1 and 100 $\mu$ g of 2, 43.3 $\mu$ g of 1 and 200 $\mu$ g of 2,  
 43.3 $\mu$ g of 1 and 300 $\mu$ g of 2, 43.3 $\mu$ g of 1 and 400 $\mu$ g of 2,  
 43.3 $\mu$ g of 1 and 500 $\mu$ g of 2, 43.3 $\mu$ g of 1 and 600 $\mu$ g of 2,  
 15 43.3 $\mu$ g of 1 and 700 $\mu$ g of 2, 43.3 $\mu$ g of 1 and 800 $\mu$ g of 2,  
 43.3 $\mu$ g of 1 and 900 $\mu$ g of 2, 43.3 $\mu$ g of 1 and 1000 $\mu$ g of 2,  
 48.1 $\mu$ g of 1 and 25 $\mu$ g of 2, 48.1 $\mu$ g of 1 and 50 $\mu$ g of 2, 48.1 $\mu$ g  
 of 1 and 100 $\mu$ g of 2, 48.1 $\mu$ g of 1 and 200 $\mu$ g of 2, 48.1 $\mu$ g of 1  
 and 300 $\mu$ g of 2, 48.1 $\mu$ g of 1 and 400 $\mu$ g of 2, 48.1 $\mu$ g of 1 and  
 20 500 $\mu$ g of 2, 48.1 $\mu$ g of 1 and 600 $\mu$ g of 2, 48.1 $\mu$ g of 1 and 700 $\mu$ g  
 of 2, 48.1 $\mu$ g of 1 and 800 $\mu$ g of 2, 48.1 $\mu$ g of 1 and 900 $\mu$ g of 2,  
 48.1 $\mu$ g of 1 and 1000 $\mu$ g of 2.

If the active substance combination in which 1 is tiotropium  
 25 bromide monohydrate is used as the preferred combination of 1  
 and 2 according to the invention, the quantities of 1' and 2  
 administered per single dose specified by way of example  
 hereinbefore correspond to the following quantities of 1 and  
2 administered per single dose: 6.2 $\mu$ g of 1 and 25 $\mu$ g of 2,  
 30 6.2 $\mu$ g of 1 and 50 $\mu$ g of 2, 6.2 $\mu$ g of 1 and 100 $\mu$ g of 2, 6.2 $\mu$ g of  
1 and 200 $\mu$ g of 2, 6.2 $\mu$ g of 1 and 300 $\mu$ g of 2, 6.2 $\mu$ g of 1 and  
 400 $\mu$ g of 2, 6.2 $\mu$ g of 1 and 500 $\mu$ g of 2, 6.2 $\mu$ g of 1 and 600 $\mu$ g  
 of 2, 6.2 $\mu$ g of 1 and 700 $\mu$ g of 2, 6.2 $\mu$ g of 1 and 800 $\mu$ g of 2,  
 6.2 $\mu$ g of 1 and 900 $\mu$ g of 2, 6.2 $\mu$ g of 1 and 1000 $\mu$ g of 2, 12.5 $\mu$ g

of 1 and 25µg of 2, 12.5µg of 1 and 50µg of 2, 12.5µg of 1  
 and 100µg of 2, 12.5µg of 1 and 200µg of 2, 12.5µg of 1 and  
 300µg of 2, 12.5µg of 1 and 400µg of 2, 12.5µg of 1 and 500µg  
 of 2, 12.5µg of 1 and 600µg of 2, 12.5µg of 1 and 700µg of 2,  
 5 12.5µg of 1 and 800µg of 2, 12.5µg of 1 and 900µg of 2,  
 12.5µg of 1 and 1000µg of 2, 22.5µg of 1 and 25µg of 2,  
 22.5µg of 1 and 50µg of 2, 22.5µg of 1 and 100µg of 2, 22.5µg  
 of 1 and 200µg of 2, 22.5µg of 1 and 300µg of 2, 22.5µg of 1  
 and 400µg of 2, 22.5µg of 1 and 500µg of 2, 22.5µg of 1 and  
 10 600µg of 2, 22.5µg of 1 and 700µg of 2, 22.5µg of 1 and 800µg  
 of 2, 22.5µg of 1 and 900µg of 2, 22.5µg of 1 and 1000µg of  
2, 25µg of 1 and 25µg of 2, 25µg of 1 and 50µg of 2, 25µg of  
1 and 100µg of 2, 25µg of 1 and 200µg of 2, 25µg of 1 and  
 300µg of 2, 25µg of 1 and 400µg of 2, 25µg of 1 and 500µg of  
 15 2, 25µg of 1 and 600µg of 2, 25µg of 1 and 700µg of 2, 25µg  
 of 1 and 800µg of 2, 25µg of 1 and 900µg of 2, 25µg of 1 and  
 1000µg of 2, 45µg of 1 and 25µg of 2, 45µg of 1 and 50µg of  
2, 45µg of 1 and 100µg of 2, 45µg of 1 and 200µg of 2, 45µg  
 of 1 and 300µg of 2, 45µg of 1 and 400µg of 2, 45µg of 1 and  
 20 500µg of 2, 45µg of 1 and 600µg of 2, 45µg of 1 and 700µg of  
2, 45µg of 1 and 800µg of 2, 45µg of 1 and 900µg of 2, 45µg  
 of 1 and 1000µg of 2, 50µg of 1 and 25µg of 2, 50µg of 1 and  
 50µg of 2, 50µg of 1 and 100µg of 2, 50µg of 1 and 200µg of  
2, 50µg of 1 and 300µg of 2, 50µg of 1 and 400µg of 2, 50µg  
 25 of 1 and 500µg of 2, 50µg of 1 and 600µg of 2, 50µg of 1 and  
 700µg of 2, 50µg of 1 and 800µg of 2, 50µg of 1 and 900µg of  
2 or 50µg of 1 and 1000µg of 2.

The active substance combinations of 1 and 2 according to the  
 30 invention are preferably administered by inhalation. For  
 this purpose, ingredients 1 and 2 have to be made available  
 in forms suitable for inhalation. Inhalable preparations  
 include inhalable powders, propellant-containing metering  
 aerosols or propellant-free inhalable solutions. Inhalable

powders according to the invention containing the combination of active substances 1 and 2 may consist of the active substances on their own or of a mixture of the active substances with physiologically acceptable excipients.

5 Within the scope of the present invention, the term propellant-free inhalable solutions also includes concentrates or sterile inhalable solutions ready for use. The preparations according to the invention may contain the combination of active substances 1 and 2 either together in

10 one formulation or in two separate formulations. These formulations which may be used within the scope of the present invention are described in more detail in the next part of the specification.

**A) Inhalable powder containing the combinations of active substances 1 and 2 according to the invention:**

15 The inhalable powders according to the invention may contain 1 and 2 either on their own or in admixture with suitable physiologically acceptable excipients.

If the active substances 1 and 2 are present in admixture

20 with physiologically acceptable excipients, the following physiologically acceptable excipients may be used to prepare these inhalable powders according to the invention:

monosaccharides (e.g. glucose or arabinose), disaccharides (e.g. lactose, saccharose, maltose), oligo- and

25 polysaccharides (e.g. dextran), polyalcohols (e.g. sorbitol, mannitol, xylitol), salts (e.g. sodium chloride, calcium carbonate) or mixtures of these excipients with one another. Preferably, mono- or disaccharides are used, while the use of lactose or glucose is preferred, particularly, but not

30 exclusively, in the form of their hydrates. For the purposes of the invention, lactose is the particularly preferred excipient, while lactose monohydrate is most particularly preferred.



Within the scope of the inhalable powders according to the invention the excipients have a maximum average particle size of up to 250 $\mu$ m, preferably between 10 and 150 $\mu$ m, most preferably between 15 and 80 $\mu$ m. It may sometimes seem

5 appropriate to add finer excipient fractions with an average particle size of 1 to 9 $\mu$ m to the excipient mentioned above. These finer excipients are also selected from the group of possible excipients listed hereinbefore. Finally, in order to prepare the inhalable powders according to the invention,

10 micronised active substance 1 and 2, preferably with an average particle size of 0.5 to 10 $\mu$ m, more preferably from 1 to 5 $\mu$ m, is added to the excipient mixture. Processes for producing the inhalable powders according to the invention by grinding and micronising and by finally mixing the

15 ingredients together are known from the prior art. The inhalable powders according to the invention may be prepared and administered either in the form of a single powder mixture which contains both 1 and 2 or in the form of separate inhalable powders which contain only 1 or 2.

20 The inhalable powders according to the invention may be administered using inhalers known from the prior art. Inhalable powders according to the invention which contain a physiologically acceptable excipient in addition to 1 and 2 may be administered, for example, by means of inhalers which

25 deliver a single dose from a supply using a measuring chamber as described in US 4570630A, or by other means as described in DE 36 25 685 A. Preferably, the inhalable powders according to the invention which contain physiologically acceptable excipient in addition to 1 and 2 are packed into

30 capsules (to produce so-called inhalettes) which are used in inhalers as described, for example, in WO 94/28958.

A particularly preferred inhaler for using the pharmaceutical combination according to the invention in inhalettes is shown in Figure 1.

This inhaler (Handyhaler) for inhaling powdered  
5 pharmaceutical compositions from capsules is characterised by  
a housing 1 containing two windows 2, a deck 3 in which there  
are air inlet ports and which is provided with a screen 5  
secured via a screen housing 4, an inhalation chamber 6  
connected to the deck 3 on which there is a push button 8  
10 provided with two sharpened pins 7 and movable counter to a  
spring 8, and a mouthpiece 12 which is connected to the  
housing 1, the deck 3 and a cover 11 via a spindle 10 to  
enable it to be flipped open or shut.

If the inhalable powders according to the invention are  
15 packed into capsules (inhalers) for the preferred use  
described above, the quantities packed into each capsule  
should be 1 to 30mg, preferably 3 to 20mg, more particularly  
5 to 10mg of inhalable powder per capsule. These capsules  
contain, according to the invention, either together or  
20 separately, the doses of 1 and 2 mentioned hereinbefore for  
each single dose.

**B) Propellant gas-driven inhalation aerosols containing the combinations of active substances 1 and 2:**

Inhalation aerosols containing propellant gas according to  
25 the invention may contain substances 1 and 2 dissolved in the  
propellant gas or in dispersed form. 1 and 2 may be present  
in separate formulations or in a single preparation, in which  
1 and 2 are either both dissolved, both dispersed or only one  
component is dissolved and the other is dispersed. The  
30 propellant gases which may be used to prepare the inhalation  
aerosols according to the invention are known from the prior  
art. Suitable propellant gases are selected from among

hydrocarbons such as n-propane, n-butane or isobutane and halohydrocarbons such as preferably fluorinated derivatives of methane, ethane, propane, butane, cyclopropane or cyclobutane. The propellant gases mentioned above may be  
5 used on their own or in mixtures thereof. Particularly preferred propellant gases are halogenated alkane derivatives selected from TG134a, TG227 and mixtures thereof.

The propellant-driven inhalation aerosols according to the invention may also contain other ingredients such as co-  
10 -solvents, stabilisers, surfactants, antioxidants, lubricants and pH adjusters. All these ingredients are known in the art.

The inhalation aerosols containing propellant gas according to the invention may contain up to 5 wt.-% of active  
15 substance 1 and/or 2. Aerosols according to the invention contain, for example, 0.002 to 5 wt.-%, 0.01 to 3 wt.-%, 0.015 to 2 wt.-%, 0.1 to 2 wt.-%, 0.5 to 2 wt.-% or 0.5 to 1 wt.-% of active substance 1 and/or 2.

If the active substances 1 and/or 2 are present in dispersed  
20 form, the particles of active substance preferably have an average particle size of up to 10µm, preferably from 0.1 to 5µm, more preferably from 1 to 5µm.

The propellant-driven inhalation aerosols according to the invention mentioned above may be administered using inhalers  
25 known in the art (MDIs = metered dose inhalers). Accordingly, in another aspect, the present invention relates to pharmaceutical compositions in the form of propellant-driven aerosols as hereinbefore described combined with one or more inhalers suitable for administering these aerosols.  
30 In addition, the present invention relates to inhalers which are characterised in that they contain the propellant gas-

containing aerosols described above according to the invention. The present invention also relates to cartridges which are fitted with a suitable valve and can be used in a suitable inhaler and which contain one of the above-mentioned  
5 propellant gas-containing inhalation aerosols according to the invention. Suitable cartridges and methods of filling these cartridges with the inhalable aerosols containing propellant gas according to the invention are known from the prior art.

10 **C) Propellant-free inhalable solutions or suspensions containing the combinations of active substances 1 and 2 according to the invention:**

It is particularly preferred to use the active substance combination according to the invention in the form of  
15 propellant-free inhalable solutions and suspensions. The solvent used may be an aqueous or alcoholic, preferably an ethanolic solution. The solvent may be water on its own or a mixture of water and ethanol. The relative proportion of ethanol compared with water is not limited but the maximum is  
20 up to 70 percent by volume, more particularly up to 60 percent by volume and most preferably up to 30 percent by volume. The remainder of the volume is made up of water. The solutions or suspensions containing 1 and 2, separately or together, are adjusted to a pH of 2 to 7, preferably 2 to  
25 5, using suitable acids. The pH may be adjusted using acids selected from inorganic or organic acids. Examples of suitable inorganic acids include hydrochloric acid, hydrobromic acid, nitric acid, sulphuric acid and/or phosphoric acid. Examples of particularly suitable organic  
30 acids include ascorbic acid, citric acid, malic acid, tartaric acid, maleic acid, succinic acid, fumaric acid, acetic acid, formic acid and/or propionic acid etc. Preferred inorganic acids are hydrochloric and sulphuric acids. It is also possible to use the acids which have

already formed an acid addition salt with one of the active substances. Of the organic acids, ascorbic acid, fumaric acid and citric acid are preferred. If desired, mixtures of the above acids may be used, particularly in the case of  
5 acids which have other properties in addition to their acidifying qualities, e.g. as flavourings, antioxidants or complexing agents, such as citric acid or ascorbic acid, for example. According to the invention, it is particularly preferred to use hydrochloric acid to adjust the pH.

10 According to the invention, the addition of editic acid (EDTA) or one of the known salts thereof, sodium editate, as stabiliser or complexing agent is unnecessary in the present formulation. Other embodiments may contain this compound or these compounds. In a preferred embodiment the content based  
15 on sodium editate is less than 100mg/100ml, preferably less than 50mg/100 ml, more preferably less than 20mg/100 ml. Generally, inhalable solutions in which the content of sodium editate is from 0 to 10mg/100ml are preferred.

Co-solvents and/or other excipients may be added to the  
20 propellant-free inhalable solutions according to the invention. Preferred co-solvents are those which contain hydroxyl groups or other polar groups, e.g. alcohols - particularly isopropyl alcohol, glycols - particularly propyleneglycol, polyethyleneglycol, polypropyleneglycol,  
25 glycolether, glycerol, polyoxyethylene alcohols and polyoxyethylene fatty acid esters. The terms excipients and additives in this context denote any pharmacologically acceptable substance which is not an active substance but which can be formulated with the active substance or  
30 substances in the pharmacologically suitable solvent in order to improve the qualitative properties of the active substance formulation. Preferably, these substances have no pharmacological effect or, in connection with the desired

therapy, no appreciable or at least no undesirable pharmacological effect. The excipients and additives include, for example, surfactants such as soya lecithin, oleic acid, sorbitan esters, such as polysorbates, polyvinylpyrrolidone, other stabilisers, complexing agents, antioxidants and/or preservatives which guarantee or prolong the shelf life of the finished pharmaceutical formulation, flavourings, vitamins and/or other additives known in the art. The additives also include pharmacologically acceptable salts such as sodium chloride as isotonic agents.

The preferred excipients include antioxidants such as ascorbic acid, for example, provided that it has not already been used to adjust the pH, vitamin A, vitamin E, tocopherols and similar vitamins and provitamins occurring in the human body.

Preservatives may be used to protect the formulation from contamination with pathogens. Suitable preservatives are those which are known in the art, particularly cetyl pyridinium chloride, benzalkonium chloride or benzoic acid or benzoates such as sodium benzoate in the concentration known from the prior art. The preservatives mentioned above are preferably present in concentrations of up to 50mg/100ml, more preferably between 5 and 20mg/100ml.

Preferred formulations contain, in addition to the solvent water and the combination of active substances 1 and 2, only benzalkonium chloride and sodium editate. In another preferred embodiment, no sodium editate is present.

The propellant-free inhalable solutions according to the invention are administered in particular using inhalers of the kind which are capable of nebulising a small amount of a liquid formulation in the therapeutic dose within a few

seconds to produce an aerosol suitable for therapeutic inhalation. Within the scope of the present invention, preferred inhalers are those in which a quantity of less than 100µL, preferably less than 50µL, more preferably between 10  
5 and 30µL of active substance solution can be nebulised in preferably one spray action to form an aerosol with an average particle size of less than 20µm, preferably less than 10µm, in such a way that the inhalable part of the aerosol corresponds to the therapeutically effective quantity.

- 10 An apparatus of this kind for propellant-free delivery of a metered quantity of a liquid pharmaceutical composition for inhalation is described for example in International Patent Application WO 91/14468 and also in WO 97/12687 (cf. in particular Figures 6a and 6b). The nebulisers (devices)  
15 described therein are known by the name Respimat®.

This nebuliser (Respimat®) can advantageously be used to produce the inhalable aerosols according to the invention containing the combination of active substances 1 and 2. Because of its cylindrical shape and handy size of less than  
20 9 to 15 cm long and 2 to 4 cm wide, this device can be carried at all times by the patient. The nebuliser sprays a defined volume of pharmaceutical formulation using high pressures through small nozzles so as to produce inhalable aerosols.

- 25 The preferred atomiser essentially consists of an upper housing part, a pump housing, a nozzle, a locking mechanism, a spring housing, a spring and a storage container, characterised by

- a pump housing which is secured in the upper housing  
30 part and which comprises at one end a nozzle body with the nozzle or nozzle arrangement,
- a hollow plunger with valve body,

- a power takeoff flange in which the hollow plunger is secured and which is located in the upper housing part,
- a locking mechanism situated in the upper housing part,
- a spring housing with the spring contained therein,
- 5       which is rotatably mounted on the upper housing part by means of a rotary bearing,
- a lower housing part which is fitted onto the spring housing in the axial direction.

The hollow plunger with valve body corresponds to a device  
10       disclosed in WO 97/12687. It projects partially into the cylinder of the pump housing and is axially movable within the cylinder. Reference is made in particular to Figures 1 to 4, especially Figure 3, and the relevant parts of the description. The hollow plunger with valve body exerts a  
15       pressure of 5 to 60 Mpa (about 50 to 600 bar), preferably 10 to 60 Mpa (about 100 to 600 bar) on the fluid, the measured amount of active substance solution, at its high pressure end at the moment when the spring is actuated. Volumes of 10 to 50 microlitres are preferred, while volumes of 10 to 20  
20       microlitres are particularly preferred and a volume of 15 microlitres per spray is most particularly preferred.

The valve body is preferably mounted at the end of the hollow plunger facing the valve body.

The nozzle in the nozzle body is preferably microstructured,  
25       i.e. produced by microtechnology. Microstructured valve bodies are disclosed for example in WO-94/07607; reference is hereby made to the contents of this specification, particularly Figure 1 therein and the associated description.

The valve body consists for example of two sheets of glass  
30       and/or silicon firmly joined together, at least one of which has one or more microstructured channels which connect the



nozzle inlet end to the nozzle outlet end. At the nozzle outlet end there is at least one round or non-round opening 2 to 10 microns deep and 5 to 15 microns wide, the depth preferably being 4.5 to 6.5 microns while the length is  
5 preferably 7 to 9 microns.

In the case of a plurality of nozzle openings, preferably two, the directions of spraying of the nozzles in the nozzle body may extend parallel to one another or may be inclined relative to one another in the direction of the nozzle  
10 opening. In a nozzle body with at least two nozzle openings at the outlet end the directions of spraying may be at an angle of 20 to 160° to one another, preferably 60 to 150°, most preferably 80 to 100°. The nozzle openings are preferably arranged at a spacing of 10 to 200 microns, more  
15 preferably at a spacing of 10 to 100 microns, most preferably 30 to 70 microns. Spacings of 50 microns are most preferred. The directions of spraying will therefore meet in the vicinity of the nozzle openings.

The liquid pharmaceutical preparation strikes the nozzle body  
20 with an entry pressure of up to 600 bar, preferably 200 to 300 bar, and is atomised into an inhalable aerosol through the nozzle openings. The preferred particle or droplet sizes of the aerosol are up to 20 microns, preferably 3 to 10 microns.

25 The locking mechanism contains a spring, preferably a cylindrical helical compression spring, as a store for the mechanical energy. The spring acts on the power takeoff flange as an actuating member the movement of which is determined by the position of a locking member. The travel  
30 of the power takeoff flange is precisely limited by an upper and lower stop. The spring is preferably biased, via a power step-up gear, e.g. a helical thrust gear, by an external

torque which is produced when the upper housing part is rotated counter to the spring housing in the lower housing part. In this case, the upper housing part and the power takeoff flange have a single or multiple V-shaped gear.

- 5 The locking member with engaging locking surfaces is arranged in a ring around the power takeoff flange. It consists, for example, of a ring of plastic or metal which is inherently radially elastically deformable. The ring is arranged in a plane at right angles to the atomiser axis. After the  
10 biasing of the spring, the locking surfaces of the locking member move into the path of the power takeoff flange and prevent the spring from relaxing. The locking member is actuated by means of a button. The actuating button is connected or coupled to the locking member. In order to  
15 actuate the locking mechanism, the actuating button is moved parallel to the annular plane, preferably into the atomiser; this causes the deformable ring to deform in the annual plane. Details of the construction of the locking mechanism are given in WO 97/20590.
- 20 The lower housing part is pushed axially over the spring housing and covers the mounting, the drive of the spindle and the storage container for the fluid.

When the atomiser is actuated the upper housing part is rotated relative to the lower housing part, the lower housing  
25 part taking the spring housing with it. The spring is thereby compressed and biased by means of the helical thrust gear and the locking mechanism engages automatically. The angle of rotation is preferably a whole-number fraction of 360 degrees, e.g. 180 degrees. At the same time as the  
30 spring is biased, the power takeoff part in the upper housing part is moved along by a given distance, the hollow plunger is withdrawn inside the cylinder in the pump housing, as a

result of which some of the fluid is sucked out of the storage container and into the high pressure chamber in front of the nozzle.

5 If desired, a number of exchangeable storage containers which contain the fluid to be atomised may be pushed into the atomiser one after another and used in succession. The storage container contains the aqueous aerosol preparation according to the invention.

10 The atomising process is initiated by pressing gently on the actuating button. As a result, the locking mechanism opens up the path for the power takeoff member. The biased spring pushes the plunger into the cylinder of the pump housing. The fluid leaves the nozzle of the atomiser in atomised form.

15 Further details of construction are disclosed in PCT Applications WO 97/12683 and WO 97/20590, to which reference is hereby made.

20 The components of the atomiser (nebuliser) are made of a material which is suitable for its purpose. The housing of the atomiser and - if its operation permits, other parts as well are preferably made of plastics, e.g. by injection moulding. For medicinal purposes, physiologically safe materials are used.

25 Figures 2a/b attached to this patent application, which are identical to Figures 6a/b of WO 97/12687, show the nebuliser (Respimat®) which can advantageously be used for inhaling the aqueous aerosol preparations according to the invention.

Figure 2a shows a longitudinal section through the atomiser with the spring biased while Figure 2b shows a longitudinal section through the atomiser with the spring relaxed.

The upper housing part (51) contains the pump housing (52) on the end of which is mounted the holder (53) for the atomiser nozzle. In the holder is the nozzle body (54) and a filter (55). The hollow plunger (57) fixed in the power takeoff  
5 flange (56) of the locking mechanism projects partially into the cylinder of the pump housing. At its end the hollow plunger carries the valve body (58). The hollow plunger is sealed off by means of the seal (59). Inside the upper  
10 housing part is the stop (60) on which the power takeoff flange abuts when the spring is relaxed. On the power takeoff flange is the stop (61) on which the power takeoff flange abuts when the spring is biased. After the biasing of the spring the locking member (62) moves between the stop (61) and a support (63) in the upper housing part. The  
15 actuating button (64) is connected to the locking member. The upper housing part ends in the mouthpiece (65) and is sealed off by means of the protective cover (66) which can be placed thereon.

The spring housing (67) with compression spring (68) is  
20 rotatably mounted on the upper housing part by means of the snap-in lugs (69) and rotary bearing. The lower housing part (70) is pushed over the spring housing. Inside the spring housing is the exchangeable storage container (71) for the fluid (72) which is to be atomised. The storage container is  
25 sealed off by the stopper (73) through which the hollow plunger projects into the storage container and is immersed at its end in the fluid (supply of active substance solution).

The spindle (74) for the mechanical counter is mounted in the  
30 covering of the spring housing. At the end of the spindle facing the upper housing part is the drive pinion (75). The slider (76) sits on the spindle.

The nebuliser described above is suitable for nebulising the aerosol preparations according to the invention to produce an aerosol suitable for inhalation.

5 If the formulation according to the invention is nebulised using the method described above (Respimat®) the quantity delivered should correspond to a defined quantity with a tolerance of not more than 25%, preferably 20% of this amount in at least 97%, preferably at least 98% of all operations of the inhaler (spray actuations). Preferably, between 5 and  
10 30 mg of formulation, most preferably between 5 and 20 mg of formulation are delivered as a defined mass on each actuation.

However, the formulation according to the invention may also be nebulised by means of inhalers other than those described  
15 above, e.g. jet stream inhalers or other stationary nebulisers.

Accordingly, in a further aspect, the invention relates to pharmaceutical formulations in the form of propellant-free inhalable solutions or suspensions as described above  
20 combined with a device suitable for administering these formulations, preferably in conjunction with the Respimat®. Preferably, the invention relates to propellant-free inhalable solutions or suspensions characterised by the combination of active substances 1 and 2 according to the  
25 invention in conjunction with the device known by the name Respimat®. In addition, the present invention relates to the above-mentioned devices for inhalation, preferably the Respimat®, characterised in that they contain the propellant-free inhalable solutions or suspensions according  
30 to the invention as described hereinbefore.

The propellant-free inhalable solutions or suspensions according to the invention may take the form of concentrates or sterile inhalable solutions or suspensions ready for use, as well as the above-mentioned solutions and suspensions  
5 designed for use in a Respimat®. Formulations ready for use may be produced from the concentrates, for example, by the addition of isotonic saline solutions. Sterile formulations ready for use may be administered using energy-operated fixed or portable nebulisers which produce inhalable aerosols by  
10 means of ultrasound or compressed air by the Venturi principle or other principles.

Accordingly, in another aspect, the present invention relates to pharmaceutical compositions in the form of propellant-free inhalable solutions or suspensions as described hereinbefore  
15 which take the form of concentrates or sterile formulations ready for use, combined with a device suitable for administering these solutions, characterised in that the device is an energy-operated free-standing or portable nebuliser which produces inhalable aerosols by means of  
20 ultrasound or compressed air by the Venturi principle or other methods.

The Examples which follow serve to illustrate the present invention in more detail without restricting the scope of the invention to the following embodiments by way of example.

25 **Starting materials**

Tiotropium bromide:

The tiotropium bromide used in the following formulations examples may be obtained as described in European Patent Application 418 716 A1.

In order to prepare the inhalable powders according to the invention, crystalline tiotropium bromide monohydrate may also be used. This crystalline tiotropium bromide monohydrate may be obtained by the method described below.

5 15.0 kg of tiotropium bromide are placed in 25.7 kg of water in a suitable reaction vessel. The mixture is heated to 80-90°C and stirred at constant temperature until a clear solution is formed. Activated charcoal (0.8 kg) moistened with water is suspended in 4.4 kg of water, this mixture is  
10 added to the solution containing the tiotropium bromide and the resulting mixture is rinsed with 4.3 kg of water. The mixture thus obtained is stirred for at least 15 minutes at 80-90°C and then filtered through a heated filter into an apparatus preheated to an external temperature of 70°C. The  
15 filter is rinsed with 8.6 kg of water. The contents of the apparatus are cooled at 3-5°C for every 20 minutes to a temperature of 20-25°C. The apparatus is cooled further to 10-15°C using cold water and crystallisation is completed by stirring for at least another hour. The crystals are  
20 isolated using a suction filter dryer, the crystal slurry isolated is washed with 9 litres of cold water (10-15°C) and cold acetone (10-15°C). The crystals obtained are dried at 25°C in a nitrogen current over a period of 2 hours. Yield: 13.4 kg of tiotropium bromide monohydrate (86% of  
25 theory).

The crystalline tiotropium bromide monohydrate thus obtained is micronised by known methods in order to prepare the active substance in the form of the average particle size corresponding to the specifications according to the  
30 invention.

**Examples of Formulations****A) Inhalable powders:**

1)

<b>Ingredients</b>	<b>µg per capsule</b>
Tiotropium bromide	21.7
AWD-12-281	200
Lactose	4778.3
<b>Total</b>	<b>5000</b>

5

2)

<b>Ingredients</b>	<b>µg per capsule</b>
Tiotropium bromide	21.7
AWD-12-281	125
Lactose	4853.3
<b>Total</b>	<b>5000</b>

3)

<b>Ingredients</b>	<b>µg per capsule</b>
Tiotropium bromide x H <sub>2</sub> O	22.5
AWD-12-281	250
Lactose	4727.5
<b>Total</b>	<b>5000</b>

10 4)

<b>Ingredients</b>	<b>µg per capsule</b>
Tiotropium bromide	21.7
AWD-12-281	250
Lactose	4728.3
<b>Total</b>	<b>5000</b>



5)

Ingredients	$\mu\text{g}$ per capsule
Tiotropium bromide x H <sub>2</sub> O	22.5
AWD-12-281	495
Lactose	4482.5
<b>Total</b>	5000

6)

Ingredients	$\mu\text{g}$ per capsule
Tiotropium bromide	21.7
AWD-12-281	400
Lactose	4578.3
<b>Total</b>	5000

5 7)

Ingredients	$\mu\text{g}$ per capsule
Tiotropium bromide x H <sub>2</sub> O	22.5
Compound of formula <b>2a</b>	250
Lactose	4727.5
<b>Total</b>	5000

B) Propellant gas-containing aerosols for inhalation:

10 1) Suspension aerosol:

Ingredients	wt.-%
Tiotropium bromide	0.015
AWD-12-281	0.066
Soya lecithin	0.2
TG 134a: TG227 = 2:3	ad 100

## 2) Suspension aerosol:

<b>Ingredients</b>	<b>wt.-%</b>
Tiotropium bromide	0.029
AWD-12-281	0.033
absolute ethanol	0.5
isopropyl myristate	0.1
TG 227	ad 100

5

## 3) Suspension aerosol:

<b>Ingredients</b>	<b>wt.-%</b>
Tiotropium bromide	0.029
AWD-12-281	0.033
absolute ethanol	0.5
isopropyl myristate	0.1
TG 227	ad 100

## 4) Suspension aerosol:

10

<b>Ingredients</b>	<b>wt.-%</b>
Tiotropium bromide	0.029
AWD-12-281	0.033
absolute ethanol	0.5
isopropyl myristate	0.1
TG 227	ad 100

## 5) Suspension aerosol:

Ingredients	wt.-%
Tiotropium bromide	0.029
Compound of formula <u>2a</u>	0.033
absolute ethanol	0.5
isopropyl myristate	0.1
TG 227	ad 100